Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 1997		**00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
The Spectral Radiative Properties of Stratus Clouds and Ice Surfaces on the Arctic	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Washington,Department of Atmospheric Sciences,Seattle,WA,98195**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**2**	

THE SPECTRAL RADIATIVE PROPERTIES OF STRATUS CLOUDS AND ICE SURFACES IN THE ARCTIC

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LONG-TERM GOALS

The heat budget of the Arctic is determined in large part by the amounts of solar radiation absorbed, reflected and transmitted by clouds, aerosols and underlying surfaces. The long-term goal of this project is to obtain measurements of these quantities that can be used in modeling studies of the heat budget of the Arctic.

OBJECTIVES

(1) To obtain airborne in situ measurements of cloud and aerosol properties in the Arctic relevant to their radiative effects.
(2) To compare in situ measurement of clouds and aerosols in the Arctic (obtained from the University of Washington's C-131A) with simultaneous remote sensing measurements of the same scenes obtained from a NASA ER-2 aircraft.
(3) To utilize an airborne, multiwavelength, scanning radiometer, built by NASA/Goddard, to measure surface reflectivities and the absorption of solar radiation by clouds in the Arctic.

APPROACH

In 1995 a series of airborne measurements (aboard the University of Washington's Convair C-131A research aircraft) were obtained in the vicinity of Prudhoe Bay and over the Beaufort Sea. These included scanning radiometer measurements of various surfaces (tundra, snow, sea ice, etc.), aerosol optical depths, aerosol properties, and cloud microstructures. On several occasions simultaneous remote sensing measurements were obtained from the NASA high-flying ER-2 aircraft. The in situ measurements we obtained on arctic clouds more than doubles the previous (scanty) data base.

WORK COMPLETED

During this reporting period, emphasis has been placed on analyses of cloud data collected in the Arctic in June 1995, and comparing it with data collected in April 1992. A comprehensive manuscript on the structure of arctic clouds was written, which has been accepted for publication in the *Quarterly Journal of the Royal Meteorological Society*.

RESULTS

1) For arctic stratiform clouds consisting entirely of drops, or of both drops and ice crystals, cloud coverage increases by 15% if the definition of a cloud is changed from 10 to 3 drops per cubic centimeter. For clouds containing ice particles, cloud coverage and/or depth increases by 40% when the definition of a cloud is changed from 1 to 0.1 ice particles per liter! These observations have some profound implications for modeling the heat budget of the Arctic.

2) Our airborne measurements on low and middle-level clouds over the Beaufort Sea in June 1995 (and April 1992) show that these clouds often have very low droplet concentrations (<100 cm^{-3}) and relatively large effective droplet radii. The collision-coalescence process is active in these clouds, leading to extensive drizzle.

3) Contrary to previous reports, our measurements show that high ice particle concentrations occur quite commonly in arctic clouds at relatively warm temperatures. Ice particle concentrations correlated quite well with the size of the largest cloud droplets.

4) The most common mixed-phased cloud encountered had a liquid-water top that precipitated ice. Such structures were observed down to -31^{o}C. This observation has important implications for the radiation balance of the Arctic.

IMPACT/APPLICATIONS

The climate of the arctic (and therefore probably the world) is extremely sensitive to cloud microstructures, which are susceptible to modification by anthropogenic influences. Our studies have documented some of these effects.

TRANSITIONS

During the next reporting period a paper should be written describing our measurements of the reflectivities of various surfaces in the Arctic. Also, another field study will be carried out in the Arctic in 1997 (as part of SHEBA/FIRE-III).

RELATED PROJECTS

1) The measuring and analysis techniques developed under this grant are directly applicable to SHEBA/FIRE-III.
2) Our collaboration with NASA/Goddard scientists under this grant has been very productive, and is providing validation data for EOS instrumentation.

REFERENCES

None

PUBLICATIONS

"Effects of Aerosols on Clouds and Radiation," by P. V. Hobbs. In *Global Energy and Water Cycles*, Ed. K. Browning and R. Gurney, Cambridge Univ. Press (In press).

"Low and Middle-Level Clouds Over the Beaufort Sea," by P. V. Hobbs and A. L. Rangno. Accepted for publication in *Q. J. Roy. Meteorol. Soc.*